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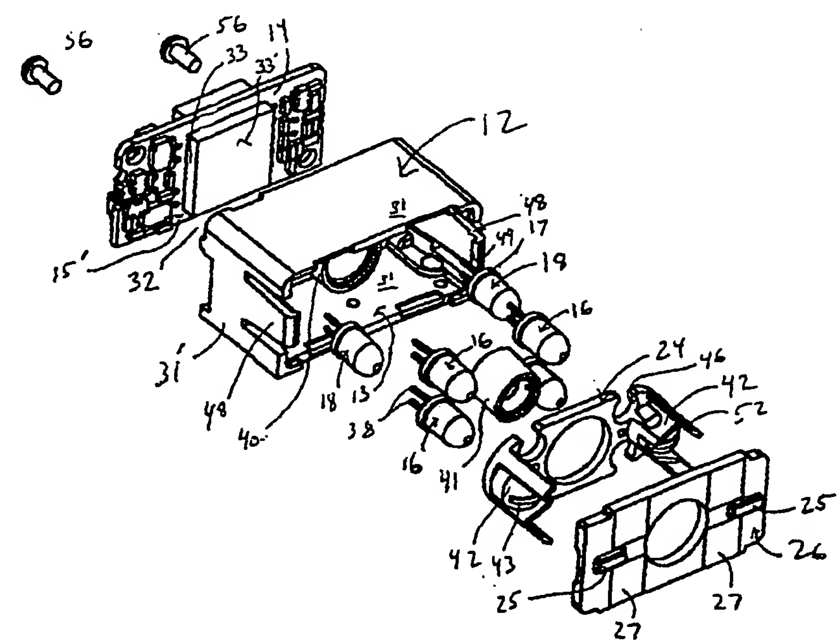
(54) Title: IMAGING MODULE FOR OPTICAL READER



(57) Abstract: The present invention is an imaging module (10) including a frame (12) supporting various optical components and a circuit board (14), which, in one embodiment, carries essentially an entirety of illumination (16) and aiming (18) LEDs of the module. The frame may include resilient fingers (48) which enable the frame to receive certain optical components in a snap-fit arrangement. Further, the module may be arranged so that the outer walls (31) and (31') of the module provide a containment for preventing structural damage to sensitive and fragile internal components of the module.

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IMAGING MODULE FOR OPTICAL READER

Field of the Invention

The present invention relates to optical reading devices in general and in particular to an apparatus for packaging illumination optical elements, receive optical elements, and signal processing elements of an optical reader.

Background of the Invention

Currently available optical readers include illumination elements, electronic signal processing circuits, image capture circuits and decoding circuits that are carried by more than one circuit board. For example, shown in U.S. Patent No. 5,780,834 is an optical reader having numerous circuit boards, including an LED board for carrying illumination LEDs, an "imaging board" carrying an image sensor and circuitry for processing signals generated from the image sensor, and a "mother board" carrying image capture and decoding circuitry. U.S. Patent No. 5,521,366 describes a modular housing having a rear printed circuit board, a front printed circuit board and a LED circuit board on which LEDs are mounted.

Assembly of a prior art reader requires mounting of separate circuit boards to separate internal structures of a reader, and providing electrical connection between the

multiple circuit boards. In addition to being difficult to assemble, the multiple circuit board design imposes size requirements on the optical reader housing in which the electrical components are to be integrated.

There is a need for an easier to manufacture and lower cost packaging apparatus for packaging optical and electrical components of an optical reader.

Summary of the Invention

According to its major aspects and broadly stated the present invention is a module for packaging optical illumination, optical receive, and electrical signal processing components of an optical reader.

The module includes a frame which carries a printed circuit board, preferably a printed circuit board (PCB) and various optical components. In one embodiment, the frame includes a back plate having a retainer for receiving an optical lens barrel, and a recess for receiving and aligning an image sensor which is carried by the PCB. The frame may also include resilient fingers which enable the frame to receive certain optical components of the module in an adhesiveless snap-fitting arrangement.

According to a preferred assembly method for assembling

the module, the PCB is first mounted onto the frame's back plate such that the image sensor of the PCB is received and aligned by the recess of the back plate. Next, illumination and aiming LEDs are soldered to the PCB to mount the LEDs. As a space conserving measure, the LEDs may be mounted so that a portion of rear surfaces of the illumination LEDs oppose a portion of the top surface of the image sensor when mounted.

After the LEDs are mounted to the PCB, additional components are incorporated in the module. In a preferred embodiment, a lens barrel is incorporated in the retainer, then an aperture plate having domed apertures for shaping light rays emanating from the aiming LEDs is placed over the LEDs. Finally, an optical plate having diffusers for diffusing light rays emanating from the illumination LEDs is snap-fit into the frame.

In addition to having diffusers for diffusing illumination light, the optical plate may also include optical elements for imaging light from the apertures onto a target defined by a reader's field of view. In one embodiment of the invention, the aiming LEDs and their associated optics project a solitary horizontal aiming line onto a target in a field of view.

The printed circuit board may be a full function printed

circuit board which carries a solid state image sensor and essentially the entirety of electronic circuitry required for supporting essentially all of the processing and control operations to be performed by the optical device in which the module is to be incorporated. Circuitry incorporated in the single PCB includes signal processing circuitry for processing signals generated from the image sensor, image capture circuitry for storing image data, and decoding and/or recognizing circuitry for decoding and/or recognizing indicia represented in image data that has been stored.

In order to accommodate the full function circuit board, the rear surface of the frame's back plate should be made to have a central recess for aligning and receiving the image sensor, and peripheral recesses for accommodating circuit elements such as electrical components and/or wiring which may emanate from the front surface of the full function printed circuit board.

These and other details, advantages and benefits of the present invention will become apparent from the detailed description of the preferred embodiment herein below.

Brief Description of the Drawings

For a fuller understanding of the nature and objects of

the invention, reference should be made to the following detailed description of a preferred mode of practicing the invention, read in connection with the accompanying drawings, in which:

Fig. 1A is a front perspective assembly diagram illustrating assembly of an image capture module according to the invention;

Fig. 1B is a rear perspective assembly diagram illustrating assembly of an image capture module according to the invention;

Fig 1C is a front perspective view of an assembled image capture module according to the invention;

Fig. 1D is a rear perspective view of an assembled image capture module according to the invention;

Fig. 1E is a representation of a preferred illumination and aiming pattern projected by a module in accordance with the invention;

Fig. 1F is a block diagram for illustration of functional and control features of the invention;

Figs. 2A - 2I are perspective views of various optical reader housings in which the invention may be incorporated;

Fig. 3 is a side view of a prior art reader illustrating a prior art multiple circuit board arrangement.

Detailed Description of the Invention

An embodiment of an imaging module 10 according to the invention is shown in Figs. 1A through 1D. Imaging module 10 is specifically designed for use in an indicia reader such as a bar code reader, an optical character recognition (OCR) reader or in a reader having both bar code and OCR reading capabilities. However, it will be understood that features of module 10 may also find use in other devices requiring image capture including video cameras, digital cameras, and medical viewing instruments.

Module 10 includes a mounting frame 12 which is adapted to receive both electrical components and optical components of an imaging system. Specifically, mounting frame 12 receives a circuit board, such as a printed circuit board (PCB) 14, illumination LEDs 16, aiming LEDs 18, aperture plate 24 and optical plate 26.

More specifically, the frame 12 includes a back plate 30 and sidewalls including top and bottom sidewalls 31 and side sidewalls 31. Back plate 30 includes a recess 34 for receiving a solid state image sensor chip 32 and a plurality of pin holes 36 for receiving leads 38 of illumination and/or aiming light sources, provided by LEDs 16 and 18. Back plate 30 further includes a retainer 40 for receiving a receive

optics lens assembly 41, e.g. a lens barrel, which may be installed in retainer 40 prior to or after any step in the assembly process as described in greater detail below.

In assembling the module 10, PCB 14 is first mounted to back plate 30 using screws 56 and frame 12 is oriented so that an opening 13 is exposed. When PCB 14 is mounted to back plate 30 the image sensor 32 carried by PCB 14 is received and aligned by center recess 34 which is shaped complimentary with the shape of image sensor 32 as shown. After mounting PCB 14 to frame 12, an assembler mounts illumination LEDs 16 and aiming LEDs 18 to PCB 14.

To mount LEDs 16 and 18 to PCB 14, the leads 38 of LEDs 16 and 18 are pushed through aligned pin holes 36 and 54 of back plate 30 and PCB 14, then the LEDs 16 and 18 are soldered to PCB 14. Preferably, all of the LEDs 16 and 18 are positioned in their respective pin holes before soldering. In soldering LEDs 16 and 18, the rear surface 15 of PCB 14 should be oriented for easy access by an assembler. To the end that LEDs 16 and 18 remain in a desired orientation which is substantially normal to PCB 14 during soldering, a standardly known fixture (not shown) shaped to receive LEDs 16 and 18 can be temporarily applied over LEDs 16 and 18 through the soldering process.

An important feature of the imaging module is that leads 38 of the illumination LEDs 16 are installed in a nearly abutting relation to sides 33 of image sensor 32 such that a portion of rear surfaces 19 of LEDs 16 oppose a portion of a front surface 33 of image sensor 32 when the LEDs 16 are completely installed. This arrangement reduces the size of the imaging module 12, enabling installation in smaller sized optical readers.

After LEDs 16 and 18 are mounted onto PCB 14 in the manner described above, the aperture plate 24 is mounted into the frame 12, the frame having domes 42 which fit over the aiming LEDs 18. The domes are preferably opaque to substantially block all light emanating from aiming LEDs 18, except light exiting the domes through slit apertures 43. Slit apertures 43 should be formed so that a desired shaped aiming pattern of illumination is projected onto a target, T. Preferably, slit apertures 43 are shaped rectangularly so that a horizontal line pattern is projected onto a target.

Aperture plate 24 further includes a number of cutaway sections 46 providing clearance to allow the aperture plate to be fitted over the illumination LEDs 16. The domes 42 and cutaway sections 46 are formed so they do not contact LEDs 16. In the embodiment shown, each LED is held in a desired

orientation while being soldered, so that the flat surfaces of LED bases 17 are biased against the flat surface of back plate 30 during the assembly process. In a further aspect, aperture plate 24 includes a shroud 58 for preventing light transmitted by the LEDs 16 and 18 from interfering with the receive optical system of the module.

After aperture plate 24 is placed over LEDs 16 and 18 and moved toward back plate 30, an optical plate 26 is snap-fitted into the opening 13 of the frame 12. Optical plate 26 includes diffusers 27 for diffusing light emanating from the illumination LEDs. In addition to having diffusers 27 formed on a front surface thereof optical plate 26 may further have wedges 28 formed on an inner surface thereof. Wedges 28 direct light from LEDs 16 toward corners of a target T so as to improve the uniformity of a target's illumination.

Resilient fingers 48 having hook ends 49 are formed in the top or side sidewalls 31 of frame 12 to enable snap-fitting of the optical plate 26 onto frame 12. In the embodiment shown, the optical plate 26 is snap-fitted onto the frame 12 by pulling back the resilient fingers 48, pushing the optical plate toward the back plate 30, then releasing the fingers 48 to lock plate 26 in position inside module 10. The aperture plate 24 includes spacers 52 which operate to bias

aperture plate 24 toward back plate 30 when optical plate 26 is snap fitted onto frame 12. The spacers 52 further transfer the force imparted by fingers 48 on optical plate 26 to the aperture plate 24, securing both the aperture plate 24 and optical plate 26 inside frame 12 without the use of adhesives or outside mechanical securing means, such as screws or pins.

Representations of an illumination pattern and an aiming pattern which may be projected by the emit optical system of module 10 are shown in Fig. 1E. In Fig. 1E, area 72 represents the region about a target area T illuminated by illumination LEDs 16 and their associated optics while area 74 represents the region about a target area highlighted by aiming LEDs 18 and their associated optics. In the embodiment of Fig. 1E aiming LEDs 18 and their associated optics project a solitary horizontal aiming line 74 onto a target area T.

The straight line aiming pattern of Fig. 1E may be generated by manufacturing plate 26 so that horizontally oriented cylindrical lenses 25 are formed on the outer surface of optical plate 26 as is shown in Fig. 1A. Horizontally oriented cylindrical lenses 25 are formed so that when plate 26 is applied over LEDs 18 lenses 25 are aligned coextensively and forwardly relative to slit apertures 43 in order to collimate and thereby image light from slit apertures 43 onto

a target T, defined by a module's field of view.

An important feature of the invention is that essentially all the illumination elements of a reader in which module 10 is to be incorporated are included on a single circuit board shown as being provided by PCB 14. This is in contrast to the design of the prior art reader shown in Fig. 3 in which illumination elements and image sensing elements are spread out over several circuit boards. In the prior art device shown in Fig. 3, an aiming illumination source 53 is mounted to a first circuit board 54, illumination LEDs are mounted to a second circuit board 56, while image sensor 32 is mounted to a third circuit board 58. The assembly of a module of this prior art design is difficult and requires material components not required by the design of the present invention including circuit boards 54, 56 and electrical connectors between the circuit boards such as connector 57. Providing a single circuit board that carries an image sensor, illumination LEDs, and aiming LEDs significantly simplifies assembly, reduces material consumption and thereby reduces the overall cost of producing the module.

Another important aspect of the invention, in one embodiment, is that essentially all electronic circuitry supporting the data processing operations required of module

10 are located on single, full function PCB 14, including circuitry for processing signals generated from image sensor 32, circuitry for capturing image data into a memory device, circuitry for decoding and/or recognizing indicia represented in captured image data. Circuitry for supporting serial transfers of data to peripheral devices may also be carried by PCB 14.

The all in one PCB arrangement of the present invention is in contrast to the traditional design in the prior art wherein circuitry for processing signals from an image sensor, circuitry for capturing and decoding image data and circuitry supporting serial interfacing with external devices are spread out over more than one circuit board.

In the design of the prior art reader shown in Fig. 3, a first vertically oriented circuit board 56 is provided for carrying circuitry for processing signals generated by an image sensor 32 and a second horizontally oriented circuit board 60, known as a "mother board" is provided for carrying circuitry for storing image data and for decoding symbologies.

The one PCB design of the present invention provides numerous advantages over the two PCB design of the prior art. The multiple circuit board arrangement of the prior art requires a complex assembly procedure wherein the first

circuit board 58 is mounted to a first internal structure of the reader in which it is incorporated, the second circuit board is mounted to a second internal structure of the reader, and then the two circuit board are electrically connected. The separate horizontal and vertical orientations of the two circuit boards 58, 60 is inefficient in terms of space consumption and imposes restrictions on the configurations of housings in which the reader optical and electrical components may be incorporated. The one full function PCB design of the present invention does not exhibit these disadvantages.

To the end that essentially the entirety of the required electronic circuitry of an optical reader can be packaged into a single printed circuit board, the back surface of the frame's back plate 30 should be configured to accommodate electrical components that will extend forward from the front surface 15 of PCB 14. Accordingly it is seen that the rear surface of back plate 30 includes a central recess 34 for aligning and receiving solid state image sensor 32 and peripheral recesses 35 for accommodating electrical circuitry such as components and/or conductors which may protrude from the front surface of PCB 14.

In addition to the features that have been described herein above, it will be seen that additional benefits are

yielded by features relating to the overall shape and configuration of module 10. As best seen in Figs. 1C and 1D, sidewalls 31 and 31' of frame 10, together with PCB 14 and plate 26 define a module having a substantially cubic rectangular overall form. The cubic rectangular form is highly space efficient relative to the form of certain optical reader imaging modules in the prior art. With reference again to Fig. 3 it is seen that the form of prior art imaging module 52 is highly irregular in that it contains members such as member 53 and member 56 that protrude extraneously from the major body of module 52. The volume conserving cubic rectangular configuration of the module of the present invention facilities incorporation of the module into optical reader housings of smaller interior volume than was possible with the irregular imaging module designs of the prior art. The volume conserving cubic rectangular form of module, in addition to facilitating incorporation of the module into a smaller volume optical reader housings, renders the module easier to package in containers containing several of the modules.

Another feature relating to the outer configuration of module 10, is that the defined outer walls of module 10 serve as a containment for protecting and preventing damage to

relatively fragile and sensitive internal components of the module. In the embodiment shown in Figs. 1A-1D, substantially all fragile sensitive components, including all light sources of module 10, and image sensor 32, are disposed inside a substantially rigid containment structure defined by sidewalls 31, 31' and PCB 12 and the combination of sidewalls 31, 31' and optical plate 26.

The substantially rigid containment of sensitive internal components of the module provided by the combination of sidewalls 31, 31' and PCB 14 and/or the combination of sidewalls 31, 31' and optical plate 26 eliminate the need to package the module with shock absorbing material such as bubble paper or foam particles during transport and allows the module to be safely transported from one location to another without substantial risk of damage to sensitive internal components.

Significantly, two of the rigid planar members defining the containment structure, namely PCB 14 and optical plate 26, provide functions important to the operation of module 10 other than the containment function. Arranging PCB 14 and optical plate 26 so that they provide containment functions in addition to the respective electrical signal processing and optical functions reduces the cost of module 10 relative to

the cost of a module in which separate rigid members are arranged to provide the containment functions provided by PCB 14 and/or plate 26 in module 10.

A block diagram illustrating one type of optical reading device in which the invention may be incorporated is described with reference to Fig. 1F.

Optical reader 110 includes an illumination assembly 120 for illuminating a target object T, such as a 1D or 2D bar code symbol, and an imaging assembly 130 for receiving an image of object T and generating an electrical output signal indicative of the data optically encoded therein. Illumination assembly 120 may, for example, include an illumination source assembly 122, such as one or more LEDs, together with an illuminating optics assembly 124, such as one or more lenses, reflectors or other optical elements such as diffusers and wedges 27 and 28, for directing light from light source 122 in the direction of target object T. The illumination assembly in the embodiment of Figs. 1A-1D is provided entirely by LEDs 16. Illumination assembly 120 may be eliminated if ambient light levels are certain to be high enough to allow high quality images of object T to be taken. Imaging assembly 130 may include an image sensor 132, such as a 1D or 2D CCD, CMOS, NMOS, PMOS, CID OR CMD solid state image

sensor, together with an imaging optics assembly 134 for receiving and focusing an image of object T onto image sensor 132. The array-based imaging assembly shown in Fig. 1F may be replaced by a laser array based imaging assembly comprising multiple laser sources, a scanning mechanism, emit and receive optics, at least one photodetector and accompanying signal processing circuitry.

Optical reader 110 of Fig. 1F also includes programmable control unit 140 which preferably comprises an integrated circuit microprocessor 142 and an application specific integrated circuit (ASIC 144). The function of ASIC 144 could also be provided by field programable gate array (FPGA). Processor 142 and ASIC 144 are both programmable control devices which are able to receive, output and process data in accordance with a stored program stored in memory unit 145 which may comprise such memory elements as a read/write random access memory or RAM 146 and an erasable read only memory or EROM 147. RAM 146 typically includes at least one volatile memory device but may include one or more long term non-volatile memory devices. Processor 142 and ASIC 144 are also both connected to a common bus 148 through which program data and working data, including address data, may be received and transmitted in either direction to any circuitry that is also

connected thereto. Processor 142 and ASIC 144 differ from one another, however, in how they are made and how they are used.

More particularly, processor 142 is preferably a general purpose, off-the-shelf VLSI integrated circuit microprocessor which has overall control of the circuitry of Fig. 2, but which devotes most of its time to decoding image data stored in RAM 146 in accordance with program data stored in EROM 147. Processor 144, on the other hand, is preferably a special purpose VLSI integrated circuit, such as a programmable logic or gate array, which is programmed to devote its time to functions other than decoding image data, and thereby relieve processor 142 from the burden of performing these functions.

The actual division of labor between processors 142 and 144 will naturally depend on the type of off-the-shelf microprocessors that are available, the type of image sensor which is used, the rate at which image data is output by imaging assembly 130, etc. There is nothing in principle, however, that requires that any particular division of labor be made between processors 142 and 144, or even that such a division be made at all. This is because special purpose processor 144 may be eliminated entirely if general purpose processor 142 is fast enough and powerful enough to perform all of the functions contemplated by the present invention.

It will, therefore, be understood that neither the number of processors used, nor the division of labor therebetween, is of any fundamental significance for purposes of the present invention.

With processor architectures of the type shown in Fig. 1F, a typical division of labor between processors 142 and 144 will be as follows. Processor 142 is preferably devoted primarily to such tasks as decoding image data, once such data has been stored in RAM 146, recognizing characters represented in stored image data according to an optical character recognition (OCR) scheme, handling menuing options and reprogramming functions, processing commands and data received from control/data input unit 139 which may comprise such elements as trigger 174 and keyboard 178 and providing overall system level coordination. Processor 144 is preferably devoted primarily to controlling the image acquisition process, the A/D conversion process and the storage of image data, including the ability to access memories 146 and 147 via a DMA channel. Processor 144 may also perform many timing and communication operations. Processor 144 may, for example, control the illumination of LEDs 122, the timing of image sensor 132 and an analog-to-digital (A/D) converter 136, the transmission and reception of data to and from a processor

external to reader 110, through an RS-232, a network such as an ethernet, or a serial bus such as USB, (or other) compatible I/O interface 137 and the outputting of user perceptible data via an output device 138, such as a beeper, a good read LED and/or a display monitor which may be provided by a liquid crystal display such as display 182. Control of output, display and I/O functions may also be shared between processors 142 and 144, as suggested by bus driver I/O and output/display devices 137′ and 138′ or may be duplicated, as suggested by microprocessor serial I/O ports 142A and 142B and I/O and display devices 137" and 138′. As explained earlier, the specifics of this division of labor is of no significance to the present invention.

In accordance with a feature of one embodiment of the invention described with reference to Figs. 1A-1D, essentially all of the electrical signal processing components described with reference to Fig. 1F may be carried by a single circuit board, PCB 14, as is indicated by dashed-in border 14, of Fig. 1F. In order to incorporate essentially all of the electrical signal processing components of Fig. 1E onto a single PCB 14, it is normally necessary to integrate several electrical components into a reduced number of electrical components. For example, using known integrated circuit fabrication

techniques, components 142, 144, 146 and 147 and interfaces 137, 137' and 137" can be incorporated in a single integrated circuit chip of reduced size. Further, as explained in an article by Eric R. Fossum entitled *Digital Camera System on a Chip*, IEEE Computer Society (IEEE Micro), Volume 18, Number 3, May/June 1998, image sensor 132, signal processing components 135, 136, and components 142, 144, 146, 147, 137, 137' and 137" may be incorporated in a single integrated circuit of reduced size.

Figs. 2A through 2H show examples of types of housings in which the present invention may be incorporated. Figs. 2A and 2B show a 1D optical reader 110-1, while Figs. 2C-2H show 2D optical readers 110-2, 110-3 and 110-4. Housing 112 of each of the optical readers 110-1 through 110-4 has incorporated therein is adapted to be graspable by a human hand and at least one trigger switch 174 for activating image capture and decoding and/or image capture and character recognition operations. Readers 110-1, 110-2 and 110-3 include hard-wired communication links 178 for communication with external devices such as other data collection devices or a host processor, while reader 110-4 includes an antenna 180 for providing wireless communication with an external device such

as another data collection device or a host processor.

In addition to the above elements, readers 110-3 and 110-4 each include a display 182 for displaying information to a user and a keyboard 184 for enabling a user to input commands and data into the reader.

Any one of the readers described with reference to Figs. 2A through 2H may be mounted in a stationary position as is illustrated in Fig. 2I showing a generic optical reader 110 docked in a scan stand 190. Scan stand 190 adapts portable optical reader 110 for presentation mode scanning. In a presentation mode, reader 110 is held in a stationary position and an indica bearing article is moved across the field of view of reader 110.

While this invention has been described in detail with reference to a preferred embodiment, it should be appreciated that the present invention is not limited to that precise embodiment. Rather, in view of the present disclosure which describes the best mode for practicing the invention, many modifications and variations would present themselves to those skilled in the art without departing from the scope and spirit of this invention, as defined in the following claims.

<u>What is claimed</u>:

1. An imaging module having a frame, a circuit board mounted to said frame, an image sensor carried by said circuit board, and at least one illumination light source for illuminating a target area, said module being characterized in that both of said image sensor and said at least one illumination light source are mounted on said circuit board.

2. The module of claim 1, further including a back plate receiving and aligning of said image sensor carried by said circuit board.

3. The module of claim 1, further including a back plate receiving said image sensor, wherein said at least one illumination light source includes a lead extending through said back plate.

4. The module of claim 1, wherein at least one light source comprises four vertically and horizontally spaced apart LEDs mounted to said circuit board.

5. The module of claim 1, wherein top, bottom, and side surfaces of said module are defined by sidewalls of said

frame, and wherein a back surface of said module is defined by said circuit board.

6. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, at least one illumination light source, and at least one aiming light source, said module being characterized in that each of said image sensor, at least one illumination light source and said at least one aiming light source are mounted on said circuit board.

7. The module of claim 6, further including a back plate receiving and aligning of said image sensor carried by said circuit board.

8. The module of claim 6, further including a back plate receiving said image sensor, wherein said at least one illumination light source includes a lead extending through said back plate.

9. The module of claim 6, wherein at least one light source comprises four vertically and horizontally spaced apart LEDs mounted to said circuit board.

10. The module of claim 6, wherein top, bottom, and side surfaces of said module are defined by sidewalls of said frame, and wherein a back surface of said module is defined by said circuit board.

11. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, and at least one illumination light source for illuminating a target area, said module being characterized in that said module includes at least one planar optical component, and wherein said frame comprises sidewalls having resilient fingers formed therein for receiving and securing said optical component in said frame in a stationary position in said frame.

12. The module of claim 11, wherein said one planar optical component carries a diffuser for diffusing light from said at least one illumination light source.

13. The module of claim 11, wherein said at least one illumination light source comprise four vertically and horizontally spaced apart LEDs, and wherein said planar optical component carries four diffusers, each diffuser diffusing light from one of said LEDs.

14. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, and at least one illumination light source for illuminating a target area, said module being characterized in that said circuit board carries said image sensor and essentially all image sensor signal processing circuitry and decoding circuitry of an optical reader in which said module is to be incorporated.

15. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, and at least one illumination light source for illuminating a target area, said module being characterized in that said frame includes substantially rigid top, bottom, and side sidewalls, and wherein said sidewalls and said circuit board define outer walls of said module.

16. The module of claim 15, wherein said sidewalls, and said plate define a substantially cubic rectangular configuration.

17. The module of claim 15, wherein said sidewalls and said circuit board define a partially enclosed contained area, and wherein said image sensor and said at least one

illumination source are contained in said contained area so that said image sensor and said sidewalls are structurally protected by said sidewalls and said circuit board.

18. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, and at least one illumination light source for illuminating a target area, said module being characterized in that said frame includes a back plate having a center recess for receiving and aligning said image sensor.

19. The imaging module of claim 18, wherein said back plate further includes at least one side recess for accommodating electrical components emanating forwardly from said circuit board.

20. An imaging module having a frame, a circuit board mounted to said frame, an image sensor, and at least one illumination light source for illuminating a target area, said module being characterized in that said module further includes a pair of aiming light sources, and a pair of slit apertures disposed forwardly of said aiming light sources.

21. The module of claim 20, wherein said module includes an aperture plate defining said slit apertures, said aperture plate being disposed over said aiming light sources.

22. The module of claim 20, wherein said module includes an aperture plate having domes fitable on said aiming light sources, wherein said slit apertures are defined in said domes.

23. The module of claim 20, wherein said module includes a pair of lens elements disposed forwardly of said pair of slit apertures for imaging said slit apertures onto a target.

24. The module of claim 20, wherein said lens elements are formed on an optical plate received by said frame.

25. An imaging module having circuit board, an image sensor carried by said circuit board and a light source having leads, characterized in that said leads are substantially abutted against a side of said image sensor and mounted to said circuit board so that a portion of said light source opposes a top surface of said image sensor, whereby space consumed by said module is conserved.

26. An optical reader comprising an imaging assembly having a field of view defining a target, and an illumination assembly characterized in that said an illumination assembly includes:

at least two rows of LEDs, each row comprising at least two LEDs;

an illumination optical assembly positioned forward of said LEDs, wherein said illumination optical assembly comprises diffusers for diffusing light from said LEDs, and wedges for directing light form said LEDs toward corners of said target.

27. The reader of claim 26, wherein said optical assembly is provided on an optical plate having light entry and light exit surfaces, wherein said diffusers are formed on said light exit surface and wherein said wedges are formed on said light exit surface.

28. The reader of claim 26, wherein there is a one to one correspondence between diffusers and LEDs of said illumination assembly.

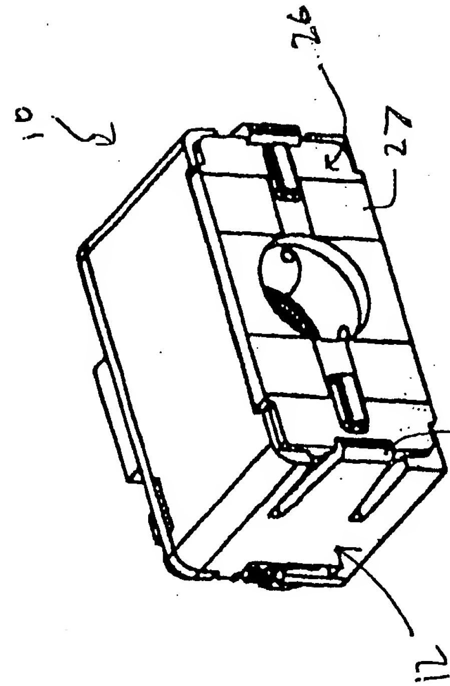
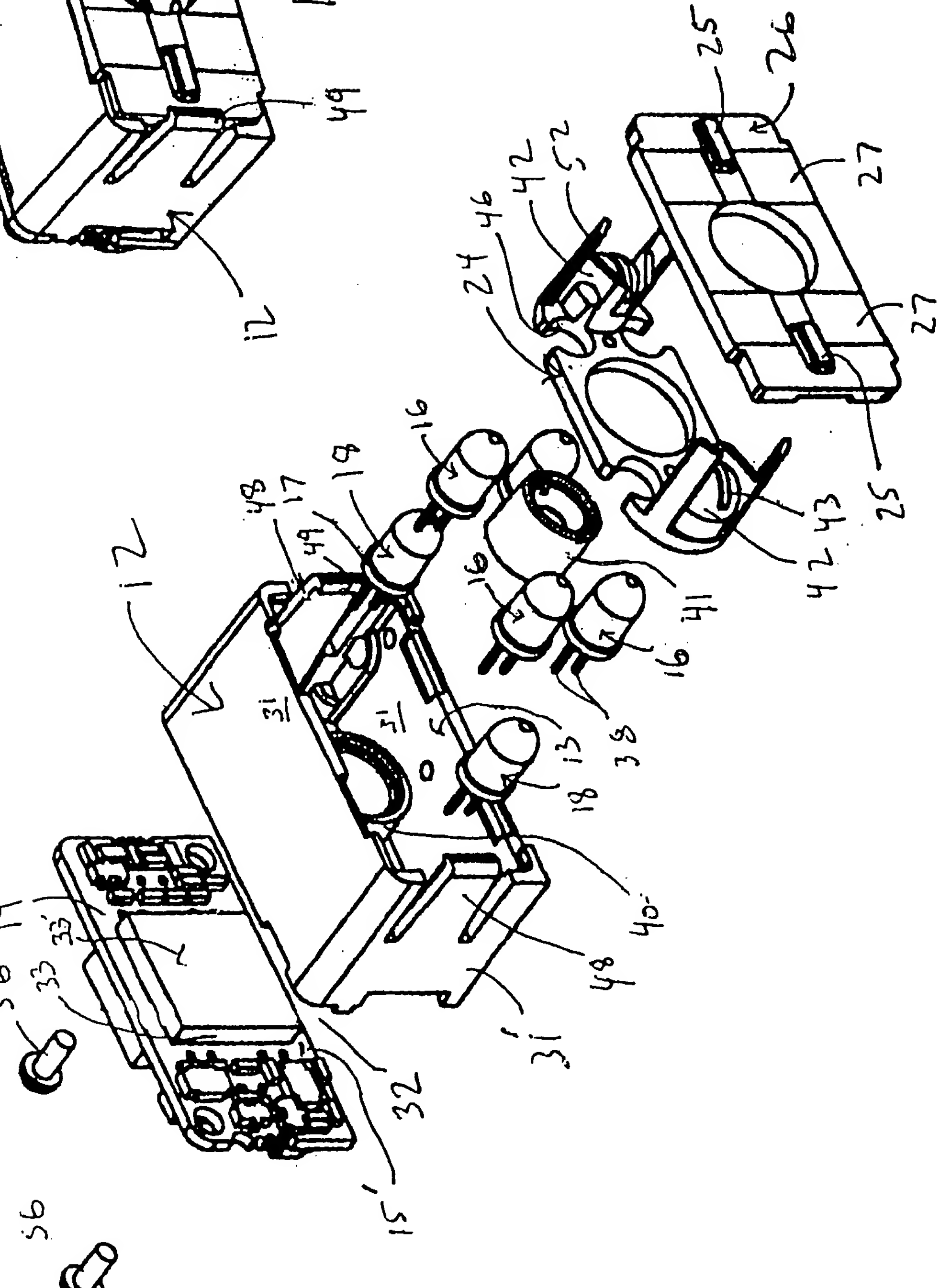

10
26
27
49
12

FIG. 1C


12
48
17
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42
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24
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42
52
25
26
27
27
40
48
31
14
33'
33
56
32
15
56

FIG. 1A

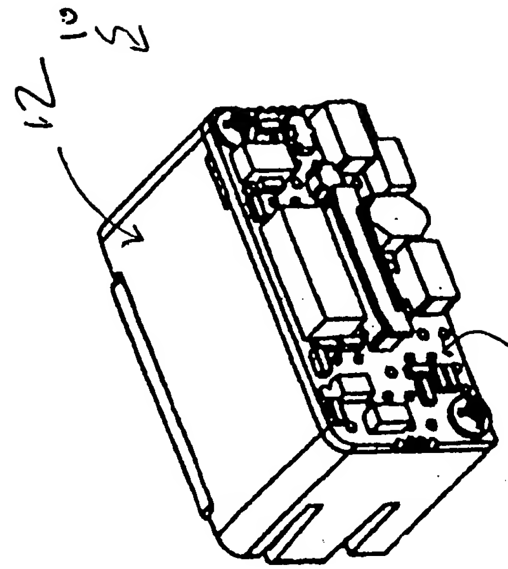
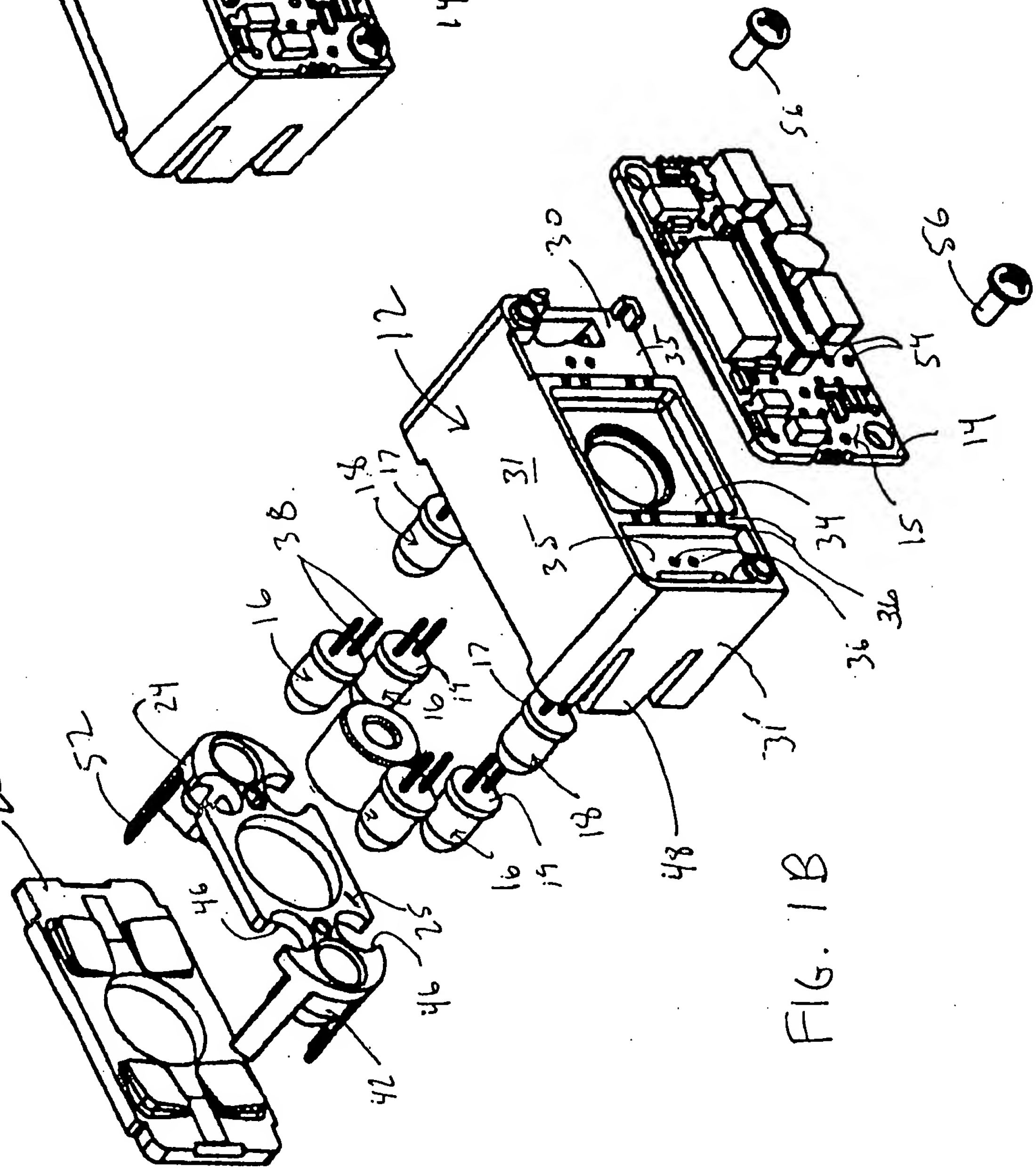

10
12
14

FIG. 1D


12
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31
32
34
35
36
38
16
17
18
14
15
54
56
48
31'
24
26
52
46
42

FIG. 1B

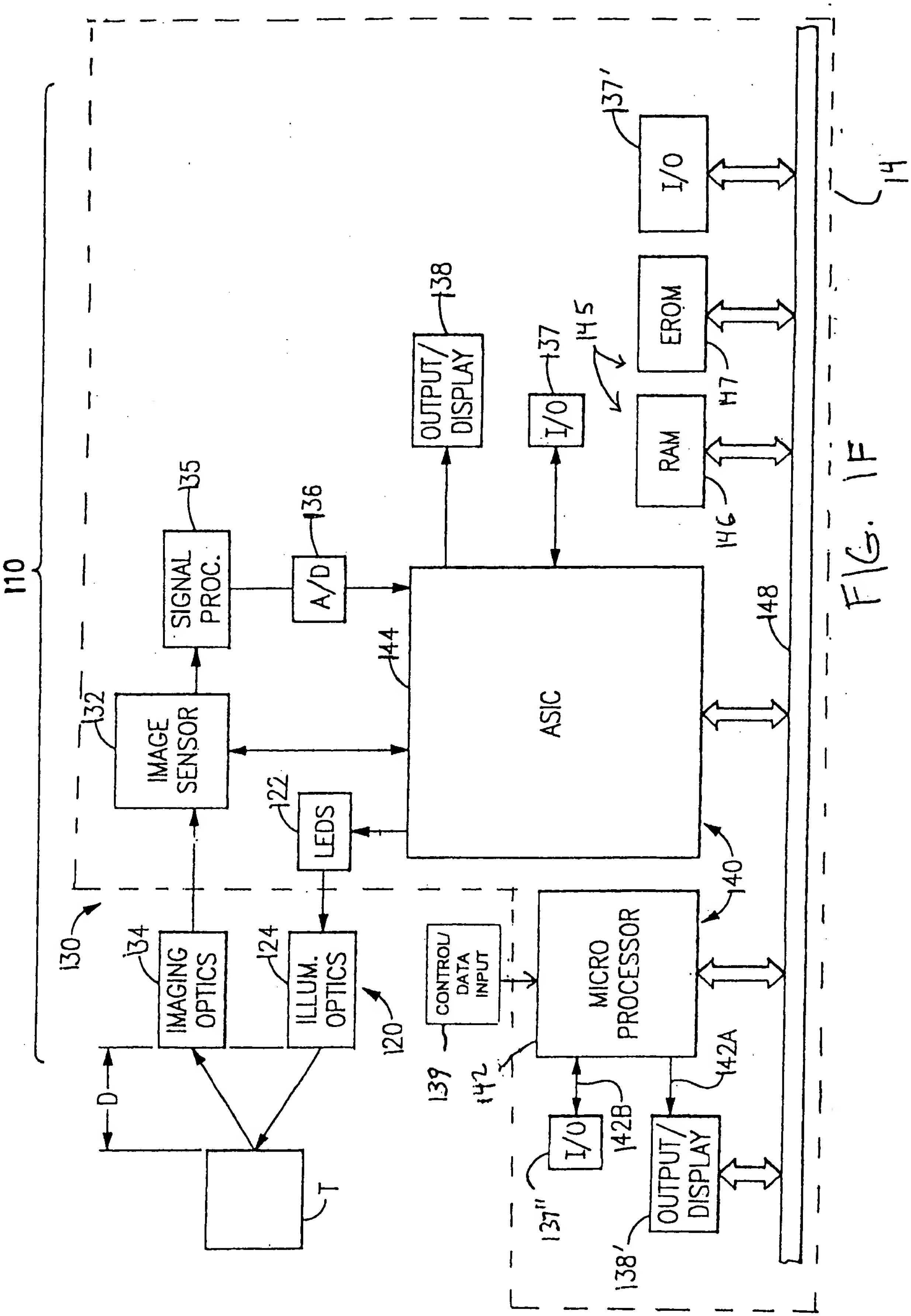
110
130
120
IMAGE SENSOR
132
SIGNAL PROC.
135
A/D
136
OUTPUT/ DISPLAY
138
I/O
137
145
LEDS
122
ASIC
144
IMAGING OPTICS
134
ILLUM. OPTICS
124
CONTROL/ DATA INPUT
139
MICRO PROCESSOR
142
140
142A
142B
I/O
137''
OUTPUT/ DISPLAY
138'
RAM
146
EROM
147
I/O
137'
148
14
D
T

FIG. 1F

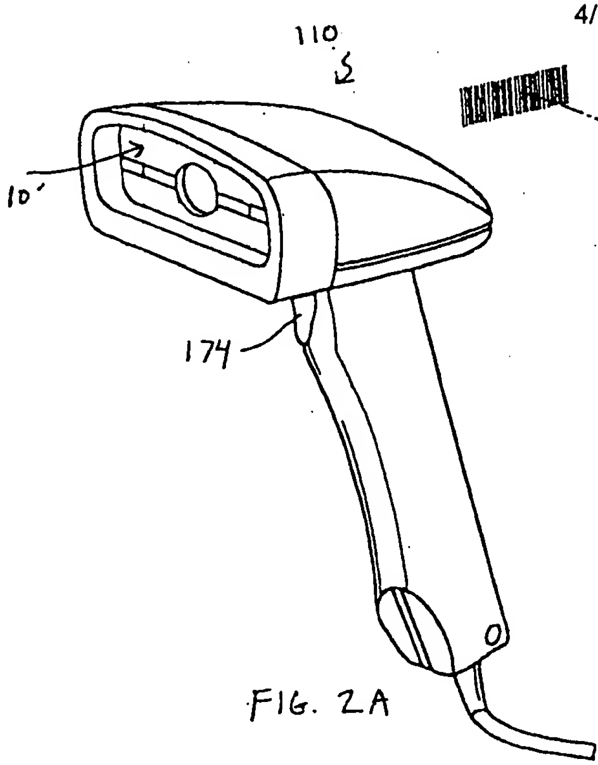

FIG. 2A

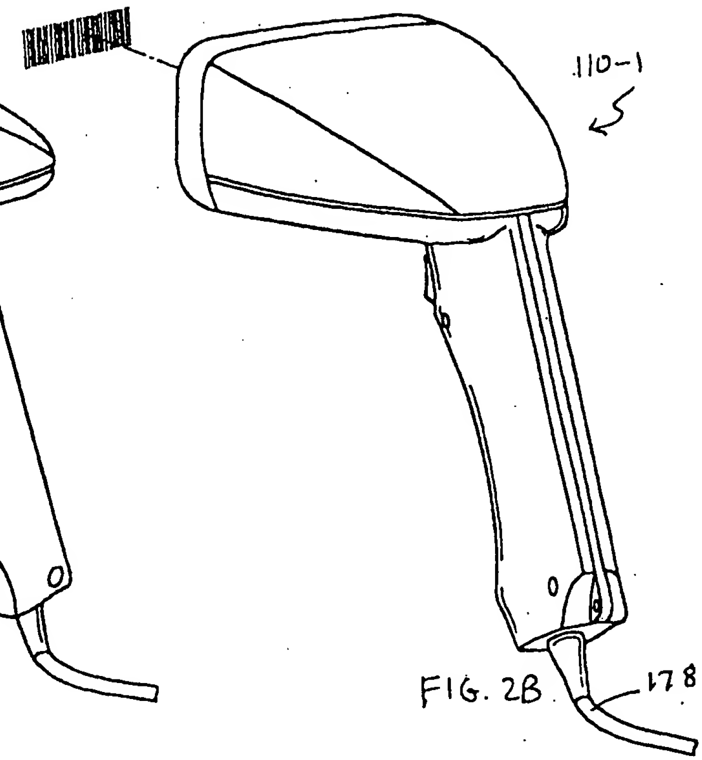

FIG. 2B

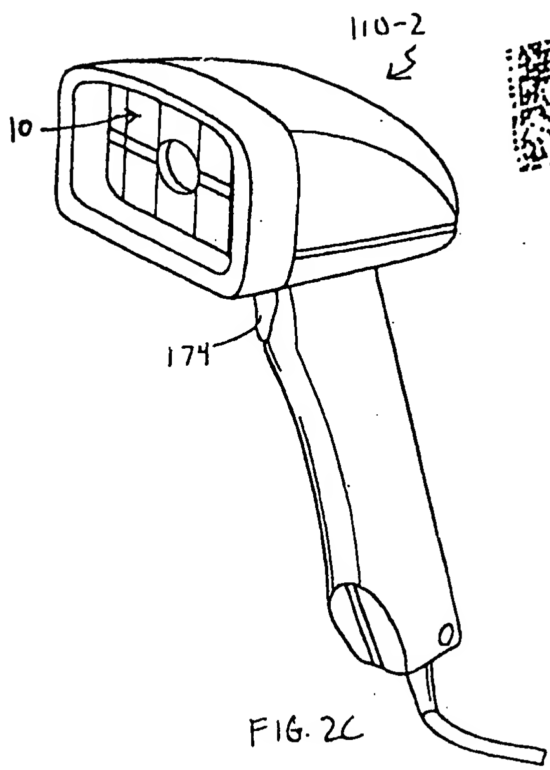

FIG. 2C

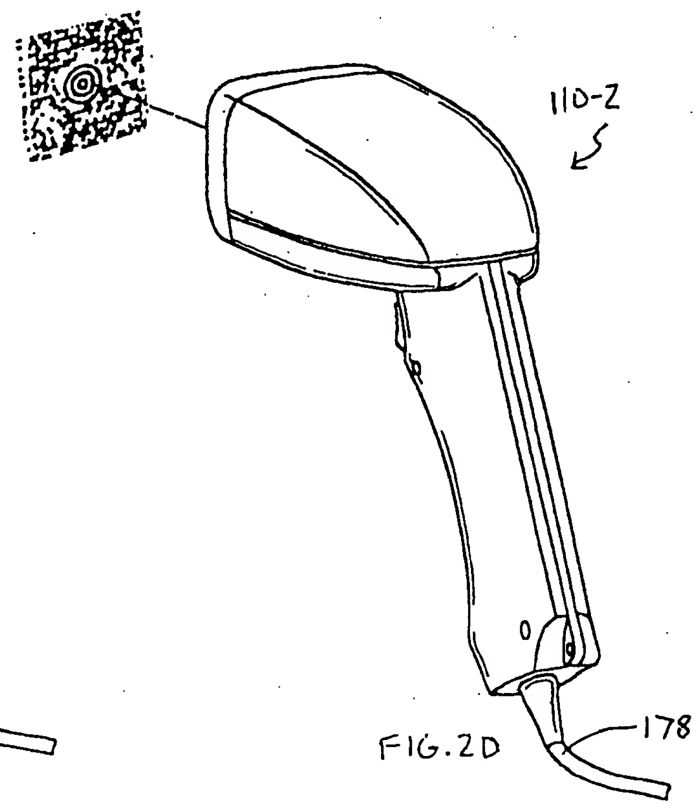

FIG. 2D

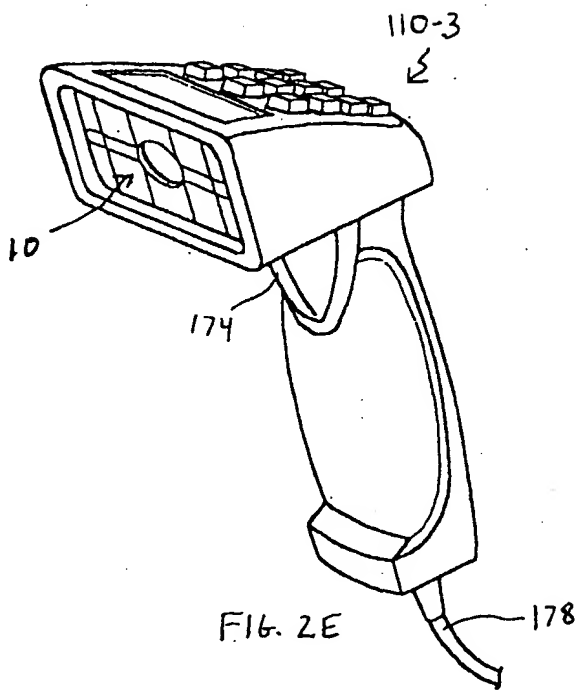

FIG. 2E

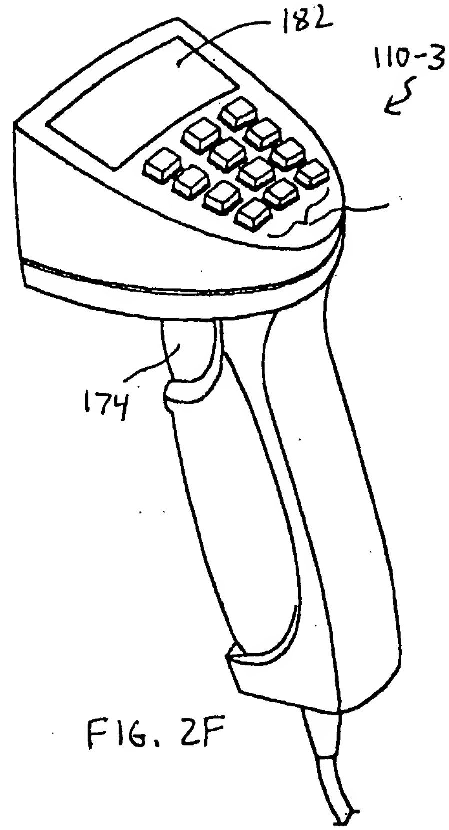

FIG. 2F

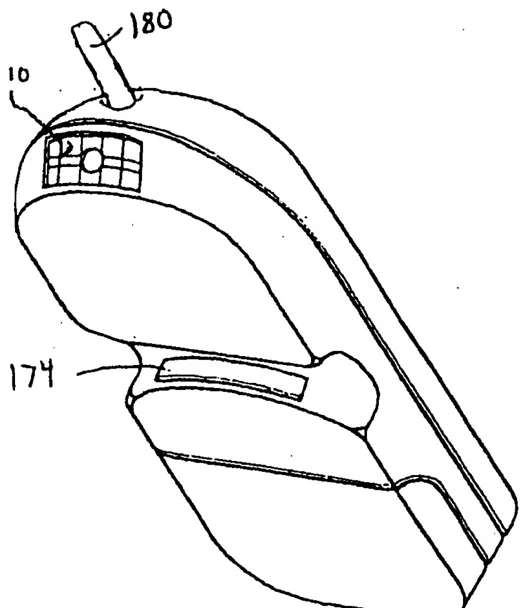

FIG. 2G

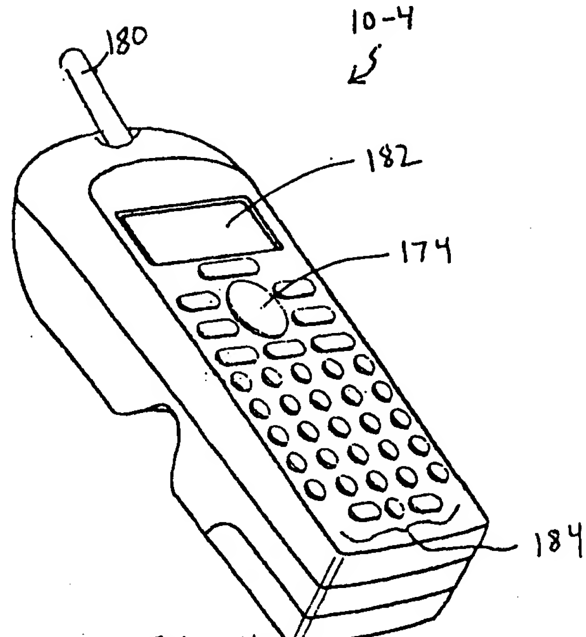

FIG. 2H

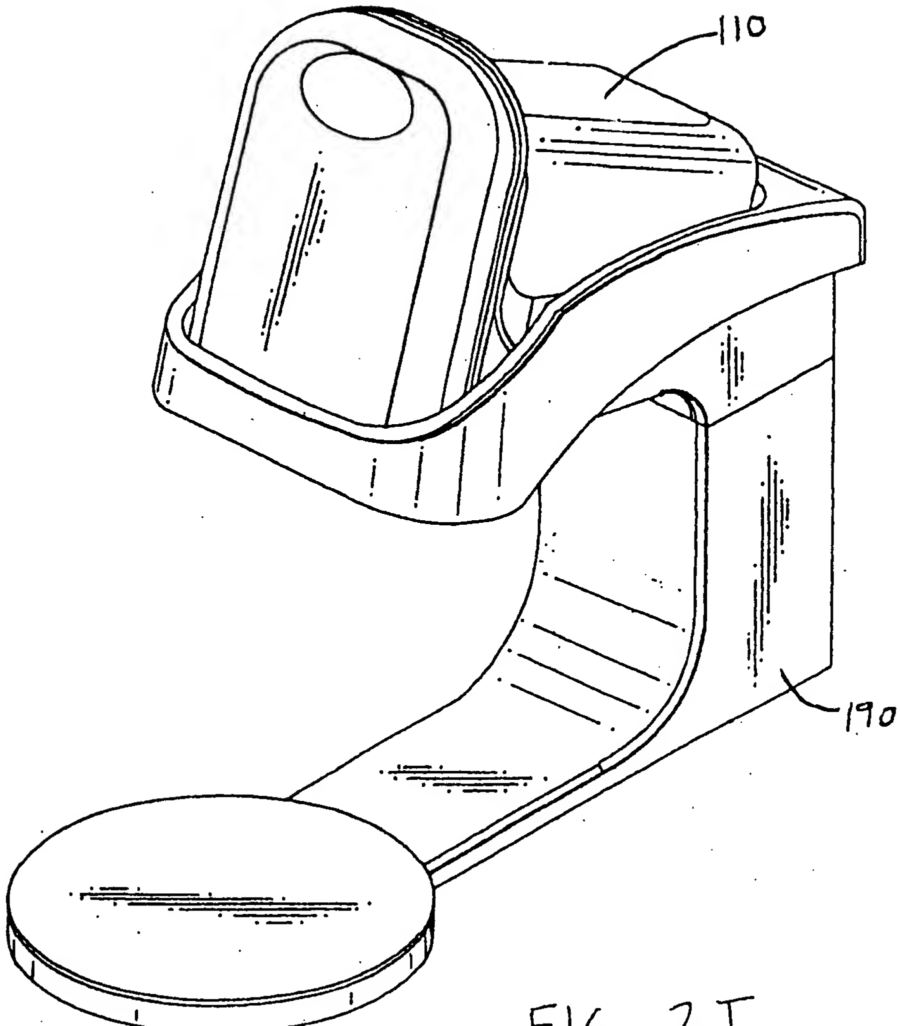

FIG. 2I

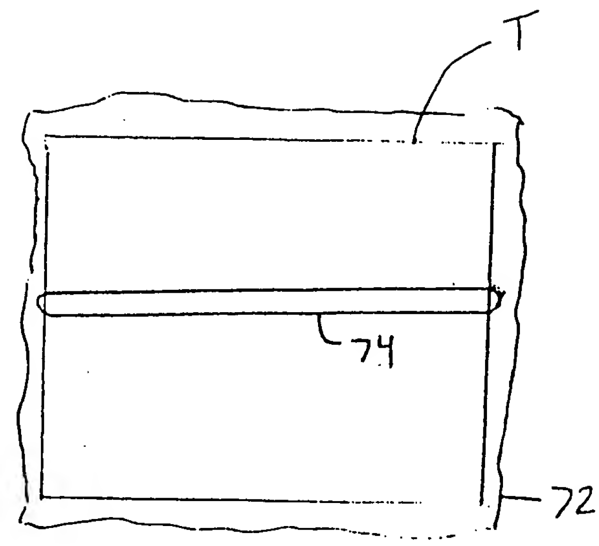

FIG. 1E

PRIOR ART

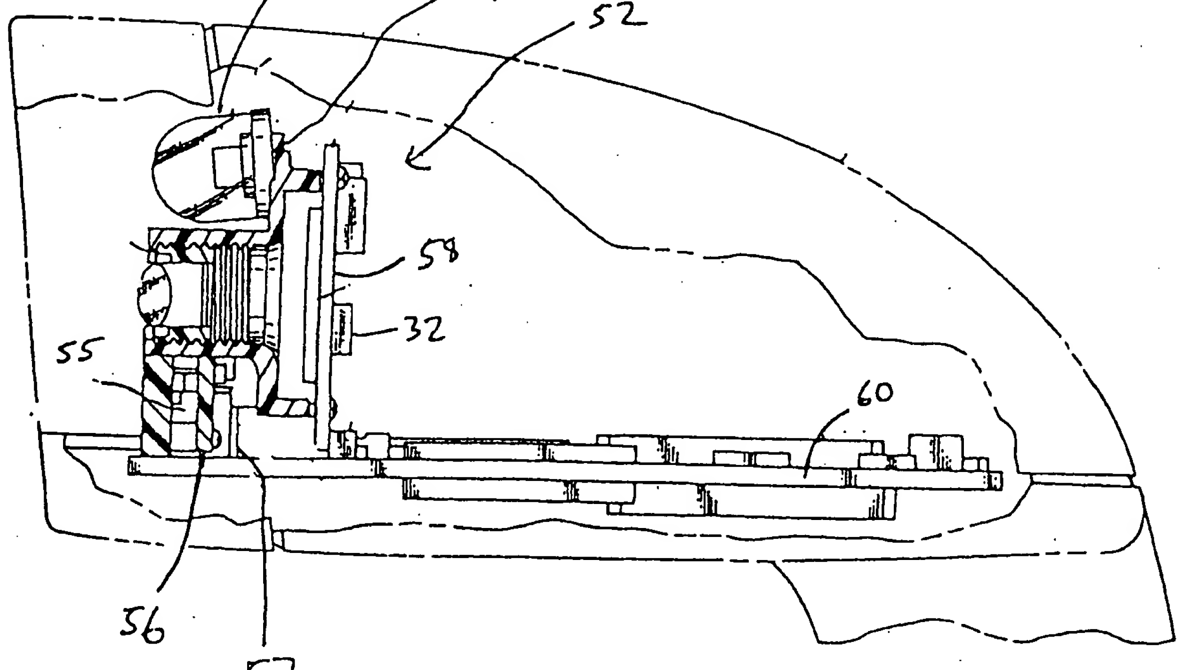

FIG. 3